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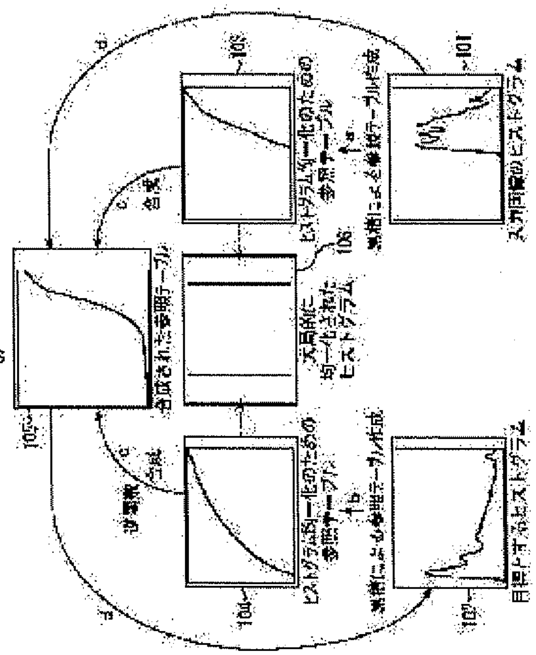
(54) DEVICE, SYSTEM, AND METHOD FOR IMAGE PROCESSING, AND STORAGE MEDIUM

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an image processor which can easily and efficiently actualize stable gradation conversion.
SOLUTION: A first means 215 obtains gradation conversion characteristics for leveling the histogram of an input image. A second means 221 obtains the reverse characteristics of the gradation conversion characteristics for leveling the histogram of the image after the specific gradation conversion. A third means 216 synthesizes the gradation conversion characteristics obtained by the 1st means 215 and the reverse characteristics obtained by the 2nd means 221. A fourth means 222 fits the composite characteristics obtained by the third means 216 with a function of lower order. According to the composite characteristics obtained by the fourth means 222, the gradations of the input image are converted.



CLAIMS

[Claim(s)]
[Claim 1] The image processing system characterized by to have an acquisition means acquire the gradation transform function which is the image processing system which performs gradation transform processing to an input image, and is made to approximate to the histogram of the image with which the histogram of the above-mentioned input image was given to predetermined gray scale conversion, and a processing means perform gradation transform processing to the above-mentioned input image based on the gradation transform function obtained by the above-mentioned acquisition means.
[Claim 2] 1st means to acquire the gradation transfer characteristic for the above-mentioned acquisition means to equalize the histogram of the above-mentioned input image, 2nd means to acquire the reverse property of the gradation transfer characteristic for equalizing the histogram of the image with which the above-mentioned predetermined gray scale conversion was performed, The image processing system according to claim 1 characterized by including 3rd means to compound the gradation transfer characteristic acquired by the 1st means of the above, and the reverse property acquired by the 2nd means of the above, and 4th means, fitting [the synthetic property acquired by the 3rd means of the above / with the function of a low degree].
[Claim 3] The 4th means of the above is an image processing system according to claim 2 characterized by having the constraint which fixed the point specified beforehand changing [concentration], and performing the above-mentioned fitting.
[Claim 4] the account of a top -- the image processing system according to claim 3 characterized by having 5th means to extract the data of the point specified beforehand changing [concentration] out of an input image.
[Claim 5] It is the image processing system according to claim 1 which is equipped with a storage means to memorize the image with which two or more above-mentioned predetermined gray scale conversion was performed, and is characterized by the above-mentioned acquisition means acquiring the gradation transform function which makes the histogram of the above-mentioned input image approximate to the histogram of the image of the arbitration of two or more images within the above-mentioned storage means.
[Claim 6] The image processing system according to claim 5 characterized by having the 1st actuation means for carrying out the external directions of the image of the above-mentioned arbitration used with the above-mentioned acquisition means.
[Claim 7] The image processing system according to claim 1 characterized by having the 2nd actuation means for making an external change of the above-mentioned predetermined gray scale conversion.
[Claim 8] The above-mentioned input image is an image processing system according to claim 1 characterized by including the image obtained by radiography.
[Claim 9] The image processing system according to claim 1 characterized by using two or more images corresponding to each photography part of the photographic subject in radiography as an image with which the above-mentioned predetermined gray scale conversion was performed.
[Claim 10] It is the image processing system which two or more devices are the image processing systems which it comes to connect possible [a communication link] mutually, and is characterized by at least one device having the function of an image processing system given in any of claims 1-10 they are among two or more above-mentioned devices.
[Claim 11] It is the image-processing approach for performing gradation transform processing to an input image. The 1st step which acquires the gradation transfer characteristic which is approximated to the histogram of the image with which gray scale conversion from which the histogram of the above-mentioned input image serves as the target concerned was performed using the image with which gray scale conversion used as the target prepared separately was performed, The image-processing approach characterized by including the 2nd step which changes the gradation of the above-mentioned input image based on the gradation transfer characteristic acquired by the 1st step of the above.

[Claim 12] The above-mentioned input image is the image-processing approach according to claim 12 characterized by including a radiation image.
[Claim 13] The 1st step of the above is the image-processing approach according to claim 12 characterized by including the step which acquires the gradation transfer characteristic [fitting / the gradation transfer characteristic which compounded the reverse property of the gradation transfer characteristic for carrying out flattening of the histogram of the image with which gray scale conversion used as the above-mentioned target was performed to the gradation transfer characteristic for carrying out flattening of the histogram of the above-mentioned input image / transfer characteristic / with the function of a low degree].
[Claim 14] The 1st step of the above is the image-processing approach according to claim 14 characterized by having the constraint which fixed the point beforehand specified on the occasion of the above-mentioned fitting changing [concentration].
[Claim 15] the 1st step of the above -- the account of a top -- the image-processing approach according to claim 15 characterized by including the step which extracts the data of the point specified beforehand changing [concentration] out of an input image.
[Claim 16] The image-processing approach according to claim 12 characterized by preparing more than one for two or more photography part of every which can set the image with which gray scale conversion used as the above-mentioned target was performed for a photographic subject.
[Claim 17] The gray scale conversion used as the above-mentioned target is the image-processing approach according to claim 12 characterized by the ability of an operator to change free.
[Claim 18] The storage characterized by storing the processing program for carrying out the function of an image processing system given in any of claims 1-10 they are, or the function of an image processing system according to claim 11 possible [read-out of a computer].
[Claim 19] The storage characterized by storing the processing step of the image-processing approach given in any of claims 12-18 they are possible [read-out of a computer].

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the storage which stored the processing step for carrying an image processing system, an image processing system, the image-processing approach, and it out used for the equipment or the system which acquires for example, a medical digital X-ray picture possible [read-out of a computer].
[0002]
[Description of the Prior Art] With digitization of the image in recent years, digitization progresses also about a medical X-ray picture, and it is possible to acquire the spatial distribution of X-ray intensity as a digital image (digital X-ray picture).
[0003] As the acquisition approach of an X-ray digital image, a latent image is formed to a photostimulable phosphor with X lineal energy. The approach of acquiring an X-ray digital image according to the excitation light distribution by laser, After changing the spatial distribution of X-ray intensity into optical intensity distribution (fluorescence) and changing into a direct electrical signal by the field sensor which has two or more pixels, the approach of changing into an X-ray digital image or the spatial distribution of X-ray intensity is changed into distribution of a direct charge, and there is the approach of acquiring an X-ray digital image etc.
[0004] As an advantage of acquiring an X-ray digital image (digitizing an X-ray picture), they are preservation of - image data, and the increase in efficiency of a transfer.
- The optimal image can be easily made by digital image processing. Thereby, the failure at the time of photography is easily recoverable.
- Efficient-izing of medical diagnostic imaging.
- Low-cost-izing of medical diagnostic imaging.
Various advantages of ** are mentioned.
[0005] Especially the advantage that the optimal image can be easily made by digital image processing is an advantage of the max using an X-ray digital image in the field of medical diagnostic imaging, and if this digital image processing does not exist, the diagnosis by the X-ray digital image cannot be considered.
[0006] First, by the approach of outputting an X-ray picture in analog to up to the film from the former, using the part with the sensitive sensitization concentration property of a film over X-ray intensity (high part of gamma), it was clear and, specifically, was made as [make / the high image of contrast]. However, control for it was mainly performed by the conditioning at the time of roentgenography, and the tolerance of the photography conditions at this time was narrow.
[0007] for example, drawing 8 -- an axis of abscissa -- X dosage and an axis of ordinate -- film density -- carrying out -- a logarithm -- the relation "C" between the incidence X dosage intensity distribution expressed-like and the film density then exposed and developed is shown.
[0008] Then, although the optimal image which has concentration distribution which is legible to observers (medical practitioner etc.) as show by "B" is obtained when optimal X dosage intensity distribution as shown by "A" are acquired in above-mentioned drawing 8 For example, if a photograph is taken with unsuitable X quality of radiation (-> short wavelength with a high bulb electrical potential difference (hand ray) -> body absorption decreases), as the dynamic range of X dosage intensity distribution shows by "D", the image of narrowing and suitable gradation will not be obtained. Such a phenomenon may happen, even when the thickness of the body which is a photographic subject is thin. Moreover, when there are too many exposed doses even if X quality of radiation is suitable as "E" shows, the whole X dosage intensity distribution shift and the image which has suitable concentration distribution also in this case too is not obtained.
[0009] On the other hand, in an X-ray digital image, various kinds of X dosage intensity distributions as shown in drawing 9 are once acquired as digital value. And the image which has the optimal gradation property (it will be a concentration property on a film if hard copy is performed) as shown in this drawing "B" according to various kinds of gradation transfer characteristics (reference table) according to X dosage intensity distribution as shown by "C1"-"C3" of above-mentioned drawing 2 is obtained, and the tolerance of the photography conditions

mentioned above spreads considerably.
[0010] Drawing 7 shows the configuration of X-rays equipment 800 which acquires the X-ray digital image which has the above advantages.
[0011] In X-rays equipment 800, by using as a photographic subject the body 802 which lies on a table, when carrying out X photography, the X-ray sensor panel 803 changes into charge distribution the intensity distribution of X dosage from X-ray tube 801 which has penetrated the body 802, and carries out a sequential output. An analog / digital transducer 805 digitizes the output of the X-ray sensor panel 803, and makes the digital image data (X-ray digital image data) once memorize to memory 806. At this time, a controller 804 controls the exposure of the X-ray in X-ray tube 801, and the timing of image acquisition.
[0012] Here, there are offset and dispersion of gain in the X-ray sensor panel 803 for every pixel. In order to amend this dispersion, the offset value which is the image acquired without carrying out exposure of the X-ray to memory 808 by X-ray tube 801 is memorized. Moreover, what carried out logarithmic transformation of the gain value which is the image acquired in the condition that there is no photographic subject (body 802) to memory 809 is memorized.
[0013] A transducer 807 performs logarithmic transformation and is specifically a reference table (look-up table).
[0014] Therefore, after the offset in memory 808 is subtracted by the subtractor 811, logarithmic transformation of the X-ray digital image data once memorized to memory 806 is carried out by the transducer 807, and they are that difference (division process) with the gain of memory 809 is taken by the subtractor 812, and serve as an intensity-distribution image of an X-ray. The intensity-distribution image of this X-ray is once memorized to memory 810. Then, the image data memorized to memory 810 is read for preservation of an image, an image processing, image display, hard copy, etc., and is used for medical diagnostic imaging etc.
[0015] Although gradation transform processing according to the gradation transfer characteristic as shown in above-mentioned drawing 9 as opposed to the image data read from memory 810 at this time is performed, in this gradation transform processing, the gradation transfer characteristic is determined as follows according to the condition at the time of acquisition of the image data (object image) concerned.
(1) Determine the gradation transfer characteristic that the concentration value (output pixel value) of the part (plurality or unit) of arbitration specified in an object image will turn into a target value.
(2) Analyze the histogram of an object image, extract the focus of the histogram concerned, and the focus determines that the gradation transfer characteristic will become a target value.
In such an approach (1) and (2), it is made as [determine / that it will become the property of approaching a target value most after expressing the gradation transfer characteristic function with the function which has a small number of parameters and reducing a degree of freedom / the parameter concerned].
[0016]
[Problem(s) to be Solved by the Invention] However, since complicated operations, such as analysis of the object image itself or analysis of the histogram of an object image, intervened, and analysis, computation, etc. took much time amount and the analysis mistake occurred depending on the object image, the conventional approaches, such as (1) which was mentioned above, or (2), had the instability of gradation transform processing.
[0017] moreover, for example, with X-rays equipment (medical X-rays equipment) as shown in above-mentioned drawing 10 Although the photography menu for performing photography and an image processing efficiently exists and the user is made as [choose / from photography menus / the item equivalent to the part (body part) of the photographic subject which it is going to photo beforehand before photography after this] There is a setting item for gradation transform processing of a part proper (setup of the parameter used for gradation transform processing) in the photography menu, respectively, and in advance, a user needs to set the parameter of gradation transform processing to it so that an observer's liking or good observation conditions may be suited. However, this setup was a very complicated activity, when there were various conditions by the part.

[0018] Then, this invention was accomplished in order to remove the above-mentioned fault, and it aims at offering the storage which stored the processing step for carrying an image processing system, an image processing system, the image-processing approach, and it out which realizes stable gray scale conversion easily and efficiently possible [read-out of a computer].
[0019]
[Means for Solving the Problem] It is characterized by to have an acquisition means acquire the gradation transform function the 1st invention is an image processing system which performs gradation transform processing to an input image, and the histogram of the image with which the histogram of the above-mentioned input image was given to predetermined gray scale conversion makes a transform function approximate under this purpose, and a processing means perform gradation transform processing to the above-mentioned input image based on the gradation transform function obtained by the above-mentioned acquisition means.
[0020] The 2nd invention is set to the 1st above-mentioned invention. The above-mentioned acquisition means 1st means to acquire the gradation transfer characteristic for equalizing the histogram of the above-mentioned input image, 2nd means to acquire the reverse property of the gradation transfer characteristic for equalizing the histogram of the image with which the above-mentioned predetermined gray scale conversion was performed, It is characterized by including 3rd means to compound the gradation transfer characteristic acquired by the 1st means of the above, and the reverse property acquired by the 2nd means of the above, and 4th means, fitting [the synthetic property acquired by the 3rd means of the above / with the function of a low degree].
[0021] 3rd invention is characterized by for the 4th means of the above having the constraint which fixed the point specified beforehand changing [concentration], and performing the above-mentioned fitting in the 2nd above-mentioned invention.
[0022] the 4th invention -- the 3rd above-mentioned invention -- setting -- the account of a top -- it is characterized by having 5th means to extract the data of the point specified beforehand changing [concentration] out of an input image.
[0023] The 5th invention is equipped with a storage means to memorize the image with which two or more above-mentioned predetermined gray scale conversion was performed in the 1st above-mentioned invention, and the above-mentioned acquisition means is characterized by acquiring the gradation transform function which makes the histogram of the above-mentioned input image approximate to the histogram of the image of the arbitration of two or more images within the above-mentioned storage means.
[0024] 6th invention is characterized by having the 1st actuation means for carrying out the external directions of the image of the above-mentioned arbitration used with the above-mentioned acquisition means in the 5th above-mentioned invention.
[0025] 7th invention is characterized by having the 2nd actuation means for making an external change of the above-mentioned predetermined gray scale conversion in the 1st above-mentioned invention.
[0026] 8th invention is characterized by the above-mentioned input image containing the image obtained by radiography in the 1st above-mentioned invention.
[0027] 10th invention is characterized by using two or more images corresponding to each photography part of the photographic subject in radiography as an image with which the above-mentioned predetermined gray scale conversion was performed in the 1st above-mentioned invention.
[0028] The 11th invention is an image processing system with which it comes to connect two or more devices of each other possible [a communication link], and at least one device is characterized by having the function of an image processing system given in any of claims 1-10 they are among two or more above-mentioned devices.
[0029] The 12th invention is the image-processing approach for performing gradation transform processing to an input image. The 1st step which acquires the gradation transfer characteristic which is approximated to the histogram of the image with which gray scale conversion from which the histogram of the above-mentioned input image serves as the target concerned was performed using the image with which gray scale conversion used as the target prepared

separately was performed, It is characterized by including the 2nd step which changes the gradation of the above-mentioned input image based on the gradation transfer characteristic acquired by the 1st step of the above.
[0030] 13th invention is characterized by the above-mentioned input image containing a radiation image in the 12th above-mentioned invention.
[0031] 14th invention is characterized by to include the step which acquires the gradation transfer characteristic [fitting / the gradation transfer characteristic which compounded the reverse property of the gradation transfer characteristic for carrying out flattening of the histogram of the image with which gray scale conversion used as the above-mentioned target was performed to the gradation transfer characteristic for the 1st step of the above carrying out flattening of the histogram of the above-mentioned input image in the 12th above-mentioned invention / transfer characteristic / with the function of a low degree].
[0032] 15th invention is characterized by the 1st step of the above having the constraint which fixed the point beforehand specified on the occasion of the above-mentioned fitting changing [concentration] in the 14th above-mentioned invention.
[0033] the 16th invention -- the 15th above-mentioned invention -- setting -- the 1st step of the above -- the account of a top -- it is characterized by including the step which extracts the data of the point specified beforehand changing [concentration] out of an input image.
[0034] 17th invention is characterized by preparing more than one for two or more photography part of every which can set the image with which gray scale conversion used as the above-mentioned target was performed for a photographic subject in the 12th above-mentioned invention.
[0035] Gray scale conversion from which the 18th invention serves as the above-mentioned target in the 12th above-mentioned invention is characterized by the ability of an operator to change free.
[0036] 19th invention is characterized by being the storage which stored the processing program for carrying out the function of an image processing system given in any of claims 1-10 they are, or the function of an image processing system according to claim 11 possible [read-out of a computer].
[0037] 20th invention is characterized by being the storage which stored the processing step of the image-processing approach given in any of claims 12-18 they are possible [read-out of a computer].
[0038]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained using a drawing.
[0039] (Gestalt of the 1st operation) There is an approach which used histogram equalization indicated by JP,11-96352,A etc. as an approach of changing the gradation transfer characteristic first used in case gradation transform processing is performed to an object image to the configuration of arbitration. The outline of this approach is explained using drawing 1 .
[0040] In above-mentioned drawing 1 , "101" shows the histogram of X dosage (pixel value) of the image (input image) of the specific part of the photographic subject (here body) acquired by roentgenography, and "103" shows the gradation translation table for performing gray scale conversion which equalizes a histogram 101.
[0041] By the technique called histogram equalization (Histogram Equalization), the gradation translation table 103 accumulates a histogram 101, and is created.
[0042] Therefore, it sets "H (x)" and a gradation translation table to "L (x)" for a histogram 101, setting the pixel value of an input image as "x" (Xmin<=x<=Xmax), and the gradation translation table 103 is [0043].
[Equation 1]

$$L(x) = Xmin + \left(\sum_{i=Xmin}^{x} H(i) \Big/ \sum_{i=Xmin}^{Xmax} H(i) \right) \times (Xmax - Xmin) \quad \cdots (1)$$

[0044] It is expressed with the becoming formula (1).
[0045] If gray scale conversion of the input image with which a histogram 101 is obtained is

carried out with the gradation translation table 103, the image which has the histogram 106 equalized on the whole will be obtained.
[0046] The image of a condition with the specific part (the same part as the part in an input image) of the photographic subject with which "102" was acquired by roentgenography ideal on the other hand The histogram (target histogram) of X dosage (pixel value) of (calling it a "target image" hereafter) is shown, and by using the above-mentioned formula (1) type also about this histogram 102 The gradation translation table 104 of histogram equalization is created, and the image which has the histogram 106 equalized on the whole is obtained.
[0047] The above-mentioned thing means that an image with the equalized histogram is convertible for the image which has the ideal histogram 102, if the translation table which has the reverse property (inverse function) of the gradation translation table 104 for obtaining a histogram 106 from the histogram 102 of a target image is created.
[0048] That is, in order to change the input image with which a histogram 101 is obtained into the target image (image of an ideal condition) with which a histogram 102 is obtained, the gradation translation table H1 (x) which equalizes the (a) histogram 101 is created.
(b) Create the gradation translation table H2 (x) which equalizes a histogram 102, and create the inverse function H2-1(x).
(c) Create convolution transformation table H0(x) =H1 (H2-1(x)) which compounded the gradation translation table H1 (x) and inverse function H2-1(x of the gradation translation table H2 (x)).
(d) Change the gradation of the input image with which a histogram 101 is obtained on the convolution transformation table H0 (x).
What is necessary is just to perform processing (a) - (d) to say.
[0049] Here, it is in special data processing of only a histogram being used for the point which should be noted by processing (a) - (d), but it analyzing the configuration of a histogram not being included. And if it sees globally, a histogram is completely in agreement with a target thing.
[0050] However, it is another talks the policy objective of wanting to observe an image good, and to make a histogram completely in agreement with the optimal thing.
[0051] Although some individual difference is since specifically photos the specific part of the body which is a photographic subject from a specific direction in the case of medical roentgenography, the histogram configuration of the photography image obtained by that cause is alike generally. So, the histogram 102 (histogram obtained from the target image of an ideal condition) shown by above-mentioned drawing 1 , i.e., the optimal histogram depending on a part, (the histogram the medical practitioner got it used to seeing, or histogram which shows human body structure clearly most) exists, and some meaning is in making the histogram of the 1st image (input image) in agreement to this histogram 102. However, even if I hear that the configuration of a histogram is alike to some extent and there is, it is meaningless to make it completely in agreement with the histogram 102 which cannot disregard the individual difference which is a photographic subject, but only makes the histogram of an input image an ideal.
[0052] That is, in above-mentioned drawing 1 , the gradation translation table 105 makes the histogram 101 of an input image completely in agreement forcibly to the ideal histogram 102, and this cannot be said to be being ideal processing.
[0053] as [approach / to the ideal histogram 102 / the histogram 101 of an input image / with the gradation translation table which consisted of functions with the low degree of freedom which changes smoothly which were used from the former ideally / most] -- it should change.
[0054] That is, near gray scale conversion can be ideally performed by determining the parameter of a function with the low degree of freedom which approximates the gradation translation table H0 (x) in the best condition to the gradation translation table H0 (x) created by the above-mentioned processing (c) and the (reference table 105 shown in above-mentioned drawing 1).
[0055] As a function with a low degree of freedom, a sigmoid function or its composition is mentioned, and if this sigmoid function or its composition prescribes an I/O function and a basis is carried out, a neural network is mentioned as a representative, for example. For example, the approach of gray scale conversion of changing the histogram of an input image into an ideal

configuration is indicated by JP,05-168615,A using the neural network.
[0056] Then, an ideal gradation transform function is acquired, without performing complicated repeat operations, such as study (back propagation error) peculiar to a neural network, with the gestalt of this operation to a technique from the former which was explained above.
[0057] That is, the gradation transform-processing approach in the gestalt of this operation is enforced by the flow of the following processing **s - **.
** Set up the configuration of the histogram made into an ideal. You may make it use a header and its histogram for the image which is the easiest to observe for an observer as a histogram here, carrying out gray scale conversion of one or two or more images conversationally.
** Create the histogram of an input image.
** Create the gradation translation table H1 (x) which equalizes the histogram of an input image.
** Create inverse function H2-1(x) of the gradation translation table which equalizes the histogram made into an ideal.
** Create convolution transformation table H0(x) =H1 (H2-1(x)) which compounded the gradation translation table H1 (x) and inverse function H2-1(x).
** Create the sigmoid function which approximates the convolution transformation table H0 (x) the best. A sigmoid function here is not limited.
** Perform gray scale conversion of an input image by using as a gradation translation table the sigmoid function called for by processing **.
[0058] Moreover, the gradation transform-processing approach in the gestalt of this operation has an advantage on actuation of the X-rays equipment or the system which acquires an X-ray digital image.
[0059] In conventional X-rays equipment or a conventional system, concrete first Since the approach of photography conditions or an image processing differs from its condition for every body part required for medical examination or a diagnosis, a user In order to perform the image processings (gradation transform processing etc.) of the proper for every part, for every part The object part needed to be chosen from the photography menu and the parameter (for example, numeric value of the conversion concentration of the object part by which automatic recognition was carried out, and conversion concentration, such as a histogram peak by which automatic recognition was carried out) of the image processing to an object part needed to be set up.
[0060] However, there is a limitation in the parameter of the image processing which a user can set up, and although the image in the condition that a user wants by setup of the parameter within the limits of [possible] this should just be obtained, a user asks for the image which has the ambient atmosphere which cannot be described in fact in many cases in the parameter or language of fractions, such as whether to be the gradation which was ready as the whole image.
[0061] Then, if a user chooses the part of arbitration from a photography menu, he will enable it to set up the image concerned or its histogram itself as a target of an image processing with the gestalt of this operation about the typical image of the selection part instead of the parameter of image processings (gradation transform processing etc.). A user creates a typical image (target image) here conversationally in advance, moving a gradation translation table. Therefore, a user should just set up the ideal image itself or its histogram rather than sets up the parameter of an image processing.
[0062] (Gestalt of the 2nd operation) This invention is applied to X-rays equipment 200 as shown in drawing 2 . This X-rays equipment 200 is equipment which enforces the image-processing approach (the gradation transform-processing approach) in the gestalt of the 1st operation.
[0063] <Configuration of X-rays equipment 200> X-rays equipment 200 X-ray tube 201 which outputs an X-ray to a photographic subject (body) 202 as shown in above-mentioned drawing 2 , The X-ray sensor panel 203 which changes into charge distribution X dosage intensity distribution of the X-ray which penetrated the photographic subject 202, and carries out a sequential output, The analog / digital converter 205 which the output of the X-ray sensor panel 203 is digitized, and is outputted as X-ray digital image data, The controller 204 which controls the exposure of the X-ray in X-ray tube 201, the timing of acquisition of X-ray digital image data, etc., The memory 206 which memorizes the X-ray digital image data outputted from an

analog / digital transducer 205, The memory 208 which memorizes the offset value which is the image acquired without carrying out exposure of the X-ray, The memory 209 which memorizes the value which carried out logarithmic transformation of the gain value which is the image acquired in the condition that there is no photographic subject 202, The subtractor 231 which performs subtraction processing of the data in memory 206 and the data in memory 208, The transducer 207 which carries out logarithmic transformation of the processing result in a subtractor 231, and the conversion result in a transducer 207 and the subtractor 232 which performs subtraction processing (division process) of the data in memory 209, The memory 210 which memorizes the processing result (intensity-distribution image data of an X-ray) in a subtractor 232, The pretreatment section 211 which pretreats to the image data in memory 210, The histogram generation section 214 which generates the histogram of the image data after pretreatment in the pretreatment section 211, The table generation section 215 which generates a histogram equalization table (gradation translation table) based on the histogram generated in the histogram generation section 214, The memory 217 which memorizes target image data, and the memory 218 which memorizes a target gradation translation table, The histogram generation section 219 which generates the histogram of the target image data in the memory 217 by which gray scale conversion was carried out with the target gradation translation table in memory 218, The table generation section 220 which generates a histogram equalization table (gradation translation table) based on the histogram generated in the histogram generation section 219, The inverse function generating section 221 which generates the inverse function of the histogram equalization table generated in the table generation section 220, The synthetic section 216 which compounds the histogram equalization table generated in the table generation section 215, and the table of the inverse function generated in the inverse function generating section 221, The fitting section [fitting / the convolution transformation table obtained in the synthetic section 216 / section / with the function of a low degree] 222, It has the memory 212 which memorizes the convolution transformation table after processing in the fitting section 222, and the image-processing section 213 which performs other image processings to the output of the pretreatment section 211 by which gray scale conversion was carried out on the convolution transformation table in memory 212.

[0064] Moreover, X-rays equipment 200 is equipped with a control panel and a display function as shown in drawing 3 .

[0065] In above-mentioned drawing 3 , "303" is a control panel which is prepared in X-rays equipment 200 body, and is operated from a user. "302 (1), 302 (2), --, 302 (8)" are two or more carbon buttons prepared on the control panel 303, and these carbon buttons 302 (1), 302 (2), --, 302 (8) are prepared corresponding to the various photography parts (the part 1 of the body, a part 2, --) of the photographic subject 202 as a photography menu. "304" is a carbon button for directing modification or a check for gradation processing conditions.

[0066] "301 (1), 301 (2), --, 301 (8)" are two or more carbon buttons 302 on a control panel 303 (1), 302 (2), --, two or more memory corresponding to 302 (8), and such memory 301 (1), 301 (2), --, 301 (8) are prepared in X-rays equipment 200. And memory 301 (1), 301 (2), --, the image (original image) made into the target of gradation processing of an object part, and its ideal gradation translation table are filed in ******** of 301 (8). For example, the image made into the target of gradation processing of a part 1 and its ideal gradation translation table are filed in the memory 301 (1) corresponding to a carbon button 302 (1). In addition, it is possible for it not to be restricted to the number and to store one or more original images and gradation translation tables as memory 301 (1), 301 (2), --, the original image memorized by ******** of 301 (8), and a gradation translation table.

[0067] "310" is the display prepared in X-rays equipment 200 body, and is made by this display 310 as [display / the original image 305, the gradation translation table 306, a histogram 307, and the image 308 after gray scale conversion].

[0068] < -- whole X-rays equipment 200: of operation -- drawing 1 above-mentioned referring-to-> -- first, by control from a controller 204, the X-ray generated from X-ray tube 201 penetrates a photographic subject 202, and reaches to up to the X-ray sensor panel 203. The X-ray sensor panel 203 changes the intensity distribution of an X-ray into charge distribution, and

carries out a sequential output. According to the control from a controller 204, an analog-to-digital converter 205 digitizes the output of the X-ray sensor panel 203, and outputs X-ray digital image data. This X-ray digital image data is X-ray digital image data of the part of the arbitration of the photographic subject 202 with which current photography is performed.
[0069] The X-ray digital image data (henceforth "input image data") outputted from the analog-to-digital converter 205 are once memorized to memory 206.
[0070] Here, there are offset and dispersion of gain in the X-ray sensor panel 203 for every pixel. Then, in order to amend this dispersion, a subtractor 231 subtracts first the offset value in memory 208 (image data acquired without carrying out exposure of the X-ray) from the input image data in memory 231. A transducer 207 is specifically a reference table (look-up table), and carries out logarithmic transformation of the input image data after subtraction processing with a subtractor 231. A subtractor 232 takes the difference of the input image data after the logarithmic transformation in a transducer 207, and the gain value in memory 209 (value which carried out logarithmic transformation of the image data acquired in the condition that there is no photographic subject 202) (division process). The input image data after subtraction processing with a subtractor 232 (intensity-distribution image data of an X-ray) is once memorized to memory 210.
[0071] The pretreatment section 211 performs an image processing required before gradation transform processing to the input image data in memory 210. The input image data after processing in this pretreatment section 211 is supplied to each of the histogram generation section 214 and memory 212, and is used for two actuation with actuation by the processing section after the histogram generation section 214, and actuation by the processing section after memory 212.
[0072] The histogram generation section 214 generates the histogram of the input image data from pretreatment 211. The table generation section 215 was generated in the histogram generation section 214, carries out histogram use, and generates a histogram equalization table (gradation translation table).
[0073] Although later mentioned for details at this time, the target image data corresponding to the part of the photographic subject 202 chosen as memory 217 from the control panel by the user is memorized. Moreover, the gradation translation table for performing gradation processing made into the target adjusted to memory 218 by the user from the above-mentioned control panel is memorized.
[0074] Therefore, the target image data in memory 217 is passing the gradation translation table in memory 218, serves as an image in which ideal gradation is shown, and is supplied to the histogram generation section 219.
[0075] The histogram generation section 219 generates the histogram of the target image data from memory 218. The table generation section 220 was generated in the histogram generation section 219, carries out histogram use, and generates a histogram equalization table (gradation translation table). The inverse function generating section 221 generates the inverse function of the gradation translation table generated in the table generation section 220.
[0076] The synthetic section 216 compounds the gradation translation table (gradation translation table generated from the histogram of an input image) generated in the table generation section 215, and the inverse function table (table of the inverse function of the gradation translation table generated from the histogram of a target image) generated in the inverse function generating section 221. Fitting [the fitting section 222 / the convolution transformation table obtained in the synthetic section 216 / with the function of a low degree]. The convolution transformation table after processing in the fitting section 222 is memorized to memory 212.
[0077] Therefore, the input image data outputted from the pretreatment section 211 to memory 212 is passing the convolution transformation table in the memory 212, is changed into the gradation for which a user asks, and is supplied to the image-processing section 213.
[0078] The image-processing section 213 performs the image processing of other arbitration to the input image data from memory 212. The input image data after this processing is used for a display, preservation, a transfer, or hard copy.

[0079] Actuation of < control panel and a display function: Drawing 3 above-mentioned referring-to-> [0080] First, when changing for example, gradation transform-processing conditions, a user pushes the gradation processing condition modification carbon button 304, chooses a carbon button 302 (1), 302 (2), --, the carbon button corresponding to the part which it is going to change out of 302 (8), and does a depression.
[0081] By this Memory 301 (1), 301 (2), --, 301 (8) inside, The original image and gradation translation table in the memory corresponding to the carbon button chosen from the user, i.e., the memory corresponding to the part which a user is going to change It is read to memory 217 and 218 (refer to above-mentioned drawing 1), respectively, and is displayed on a display 310 as the original image 305 and a gradation translation table 306. And the histogram generation section 220 (refer to above-mentioned drawing 1) generates the histogram of the original image in memory 217. This generated histogram is displayed on a display 310 as a histogram 307. Since a change of the gradation translation table 306 from a user is not yet made at this time, the image of the same condition as the original image 305 is displayed on a display 310 as an after [conversion] image 308.
[0082] Next, a user changes the gradation translation table 306 conversationally, checking the original image 305 displayed on the display 310.
[0083] According to modification of this gradation translation table 306, the gradation translation table in memory 218 (refer to above-mentioned drawing 1) is also changed. Thereby, the original image in memory 217 is passing the gradation translation table after modification in memory 218, turns into an image of the gradation based on the modification concerned, and is displayed on a display 310 as an after [conversion] image 308. Moreover, the histogram generation section 220 (refer to above-mentioned drawing 1) generates the histogram of the original image after the gray scale conversion which passed memory 218. This generated histogram is displayed on a display 310 as a histogram 307.
[0084] And a user does the depression of the gradation processing condition modification carbon button 304 again, after adjusting so that it may become the image which suited liking and completing this adjustment by conversational modification of the gradation translation table 306, or it is easier to observe the image 308 after gray scale conversion for itself. Thereby, the gradation translation table in the memory 218 at this time is registered as a gradation translation table of the target image actually used for processing. In addition, you may make it register the histogram in memory 220 itself with registration of a gradation translation table.
[0085] If the gradation translation table in memory 218 is registered as a gradation translation table of a target image as mentioned above, in the gradation translation table, processing with X-rays equipment 200 which was explained by <refer to [X-rays equipment / whole / 200] of operation : above-mentioned drawing 1 > will be performed.
[0086] Drawing 4 shows the processing flow chart of the software program concerned for carrying out gradation transform processing in above X-rays equipment 200 by the software program.
[0087] First, a user chooses the carbon button 302 of a control panel 303 (1), 302 (2), --, the part that a photographic subject 202 photos by 302 (8) (step S401).
[0088] The original image and gradation translation table memory 301 (1), 301 (2), --, in the memory corresponding to the above-mentioned selection carbon button among 301 (8) are read by the selection actuation from the user in step S401, respectively (step S402). It is displayed on a display 310 as these original images and a gradation translation table, the original image 305, and a gradation translation table 306.
[0089] Next, the histogram of the image after carrying out gray scale conversion of the original image read at this step with the gradation translation table read at step S402 is generated (step S403). The histogram generated at this step S403 is displayed on a display 310 as a histogram 307.
[0090] And if adjustment actuation of the gradation translation table from a user is performed, according to the adjustment actuation, the gradation translation table 306 in a display 310, a histogram 307, and the image 308 after conversion will be changed and displayed.
[0091] Next, a user's termination of the above-mentioned adjustment actuation creates the

conversion translation table for equalizing the histogram generated at step S403 at this time (step S404).
[0092] Next, the inverse function table of the gradation translation table boiled and created at step S404 is created (step S405).
[0093] On the other hand, the photography image data (input image data) of a photographic subject is acquired by roentgenography (step S406).
[0094] Next, the histogram of the input image data acquired at step S406 is generated (step S407).
[0095] Next, the gradation translation table for equalizing the histogram generated at step S407 is created (step S408).
[0096] After processing of steps S401-S408 is completed, the inverse function table obtained at step S405 and the gradation translation table obtained at step S408 are compounded, and a convolution transformation table is generated (step S409).
[0097] And gradation transform processing is performed to the input image data which the convolution transformation table obtained at step S409 with the function of a low degree (step S410), and was obtained at step S406 using the convolution transformation table after the fitting (step S411).
[0098] In addition, when creating the gradation translation table of histogram equalization, you may make it the information on invalid parts, such as background information on an object image, deleted or disregarded out of a histogram.
[0099] (Gestalt of the 3rd operation) First, although the vanity condition of the whole image is mostly attained by making the histogram approximate to a target histogram, by the medical image, to fix the pixel value (concentration value) of a further specific part, and to attain the stable diagnostic ability is desired.
[0100] So, with the gestalt of this operation, it applies to X-rays equipment 500 as shows this invention to drawing 5 . Although this X-rays equipment 500 is considered as the same configuration as X-rays equipment 200 of above-mentioned drawing 2 , having considered as the configuration which formed the pixel value information extract section 523 further especially to the requirements for a configuration with which X-rays equipment 200 is equipped differ.
[0101] In addition, in X-rays equipment 500 of above-mentioned drawing 5 , the same sign is given to the part which operates like X-rays equipment 200 of above-mentioned drawing 2 , and the detailed explanation is omitted.
[0102] namely, in X-rays equipment 500 in the gestalt of this operation While filing the memory 301 (1) shown in above-mentioned drawing 3 , 301 (2), --, the image (original image) made into the target of gradation processing of an object part, and its ideal gradation translation table to 301 (8) Convention default {y(j);=0 as a concentration value (the last pixel value) of an object part, --, n;n also file one or more integers}.
[0103] Therefore, when a photography part is chosen from a user with a control panel 303, as for an original image and gradation translation table and convention default {y(j);=0, --, n;n, one or more integers} will be read from the memory corresponding to the selection.
[0104] In the pixel value information extract section 523, pixel value (unit or two or more pixel values) {x(j);=0 of a regular part, --, n;n extract one or more integers} from the input image data after processing in the pretreatment section 211. The approach and the object image itself which extract the average of the pixel value of the pixel circumference of the location of the convention in the approach of extracting the pixel value of the location of the convention in an object image, and an object image, for example as an extraction method of the pixel value in the pixel value information extract section 523 analyze, a specific part detects from the configuration of the photographic subject field in an object image, and there is a method of extracting the average of the pixel value of the location or the pixel value of the circumference of it etc.
[0105] Although the fitting section 222 was the processing section [fitting / section / the function of a low degree] with the gestalt of the 2nd operation With the gestalt of this operation, pixel value (unit or two or more pixel values) {x(j);=0, --, n;n which were obtained in the pixel value information extract section 523 receive one or more integers}. n;n performs fitting with

above-mentioned convention default {y(j);=0 and -- which were read at the time of selection of a user's photography part, and the constraint that one or more integers} corresponds.
[0106] Drawing 6 shows the situation of fitting in the fitting section 222 in the gestalt of this operation. As shown in this drawing 6 , when it is referred to as n= 2, although fitting is carried out with the function 601 of a low degree, fitting of the function 602 of the convolution transformation table obtained by the synthetic section 216 (when the concentration of the pixel of two points is doubled) is carried out at this time so that it may become the value of y (2) to y (1) and x (2) as a constraint to x (1). In addition, as a parameter of a function, at least two or more pieces are required.
[0107] The processing flow chart of the software program concerned for carrying out gradation transform processing in above X-rays equipment 500 by the software program comes to be shown in drawing 7 . Namely, pixel value (unit or two or more pixel values) {x(j);=0 of the part of the input image data convention acquired at step S406, --, step S700 from which n;n extracts one or more integers} are added to the flow chart shown in above-mentioned drawing 4 . In fitting processing at step S410 Pixel value (unit or two or more pixel values) {x(j);=0, --, n;n which were obtained at step S700 receive one or more integers}. n;n performs fitting with above-mentioned convention default {y(j);=0 and -- which were read at the time of selection of the photography part of the user in step S401, and the constraint that one or more integers} corresponds.
[0108] In addition, it cannot be overemphasized by the purpose of this invention supplying the storage which memorized the program code of the software which realizes the host of the gestalt of the 1st - the 3rd operation, and the function of a terminal to a system or equipment, and reading and performing the program code with which the computer (or CPU and MPU) of the system or equipment was stored in the storage that it is attained. In this case, the program code itself read from the storage will realize the function of the gestalt of the 1st - the 3rd operation, and the storage which memorized that program code will constitute this invention. As a storage for supplying a program code, the memory card of ROM, a floppy disk, a hard disk, an optical disk, a magneto-optic disk, CD-ROM, CD-R, a magnetic tape, and a non-volatile etc. can be used. Moreover, it cannot be overemphasized by performing the program code which the computer read that it is contained also when the function of the gestalt of the 1st - the 3rd operation is not only realized, but it performs a part or all of processing that OS which is working on a computer is actual, based on directions of the program code and the function of the gestalt of the 1st - the 3rd operation is realized by the processing. Furthermore, after the program code read from the storage was written in the memory with which the functional expansion unit connected to the extension board inserted in the computer or the computer is equipped, It cannot be overemphasized that it is contained also when a part or all of processing that CPU with which the functional add-in board and functional expansion unit are equipped is actual is performed based on directions of the program code and the function of the gestalt of the 1st - the 3rd operation is realized by the processing.
[0109]
[Effect of the Invention] As explained above, the images (typical target image etc.) with which predetermined gray scale conversion was performed according to this invention are made into the index of gray scale conversion, and since it constituted so that the histogram of the image by which the histogram of an input image was given to predetermined gray scale conversion according to the gradation transfer characteristic in the function of a low degree etc. might be made to resemble, the gray scale conversion for which it stabilizes and asks is easily realizable.

[Translation done.]

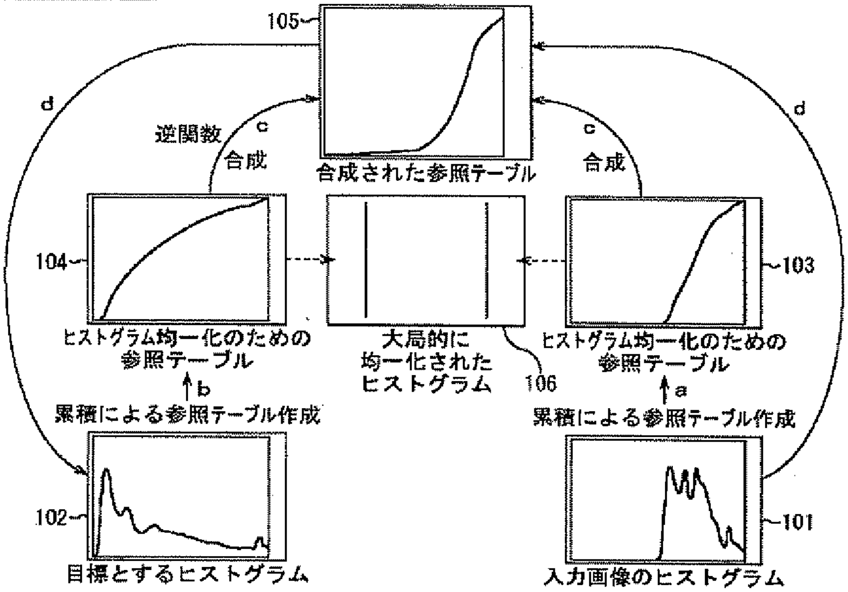
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] In the gestalt of the 1st operation, it is drawing for explaining the image-processing approach (the gradation transform-processing approach) which applied this invention.
[Drawing 2] In the gestalt of the 2nd operation, it is the block diagram showing the configuration of the X-rays equipment which applied this invention.
[Drawing 3] It is drawing for explaining the control panel of the above-mentioned X-rays equipment, and the configuration of a display.
[Drawing 4] It is a flow chart for explaining processing by the software program concerned for operating the above-mentioned X-rays equipment by the software program.
[Drawing 5] In the gestalt of the 3rd operation, it is the block diagram showing the configuration of the X-rays equipment which applied this invention.
[Drawing 6] It is drawing for explaining fitting processing with the above-mentioned X-rays equipment.
[Drawing 7] It is a flow chart for explaining processing by the software program concerned for operating the above-mentioned X-rays equipment by the software program.
[Drawing 8] It is drawing for explaining the gradation property by the conventional film.
[Drawing 9] It is drawing for explaining the gray scale conversion of an X-ray digital image.
[Drawing 10] It is the block diagram showing the configuration of the conventional X-rays equipment.
[Description of Notations]
200 X-rays Equipment
201 X-ray Tube
202 Photographic Subject
203 X-ray Sensor Panel
204 Controller
205 Analog / Digital Converter
206 Memory
207 Converter (Logarithmic Transformation Machine)
208 Memory (Offset Value)
209 Memory (Gain Value)
210 Memory (Intensity-Distribution Image Data of X-ray)
211 Pretreatment Section
212 Memory (Gradation Translation Table)
213 Image-Processing Section
214 Histogram Generation Section
215 Table Generation Section
216 Synthetic Section
217 Memory (Target Image)
218 Memory (Target Gradation Translation Table)
219 Histogram Generation Section
220 Table Generation Section
221 Inverse Function Generating Section
222 Fitting Section
231,232 Subtractor

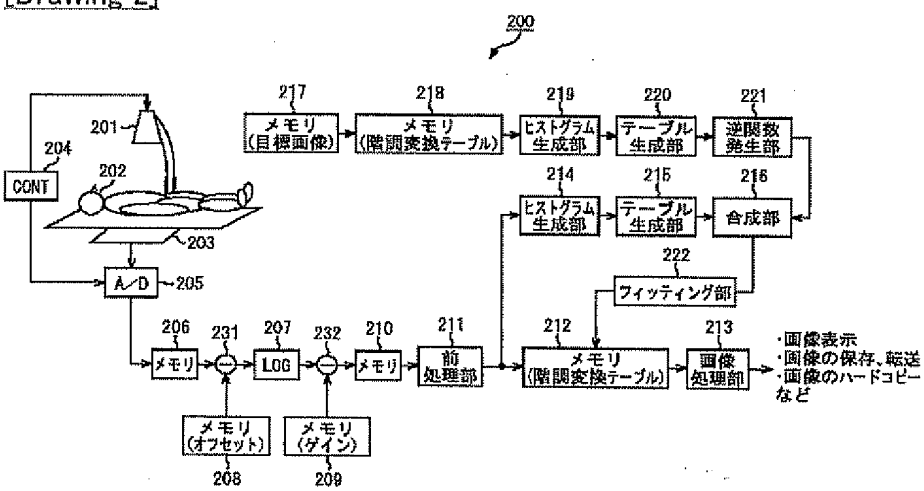
[Translation done.]

DRAWINGS

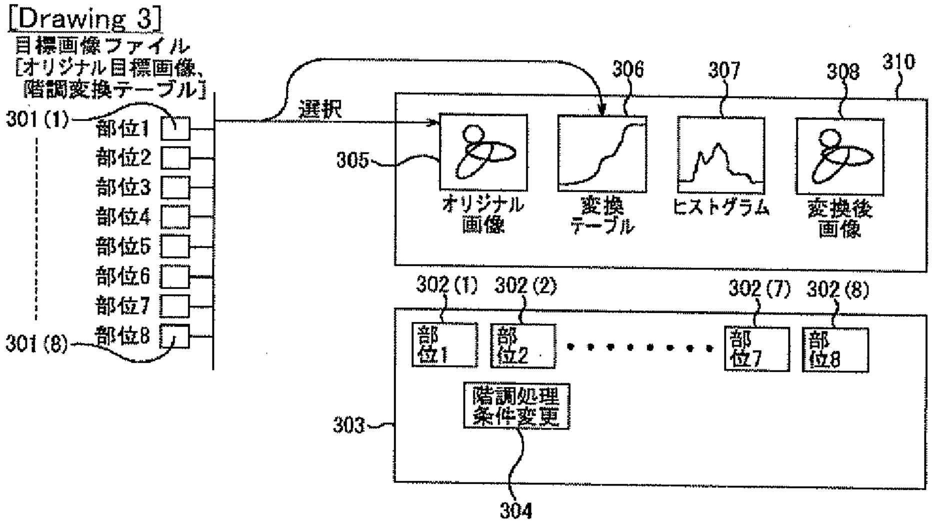
[Drawing 1]



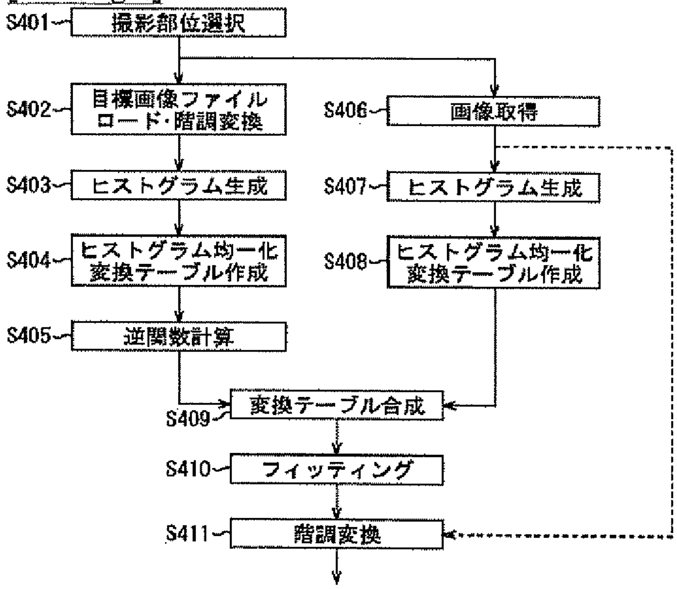
[Drawing 2]



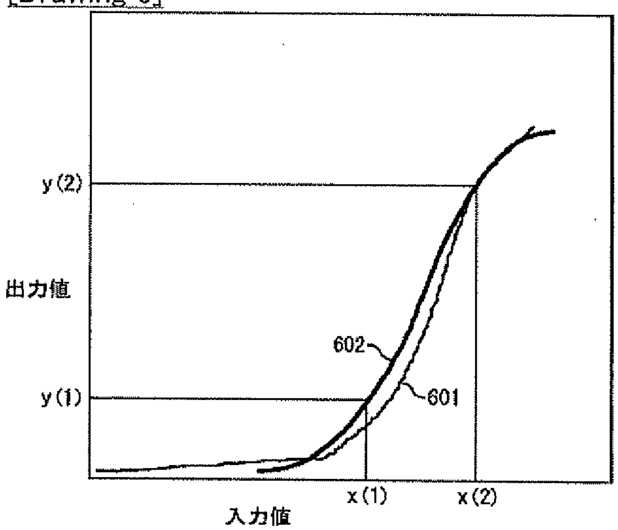
[Drawing 3]



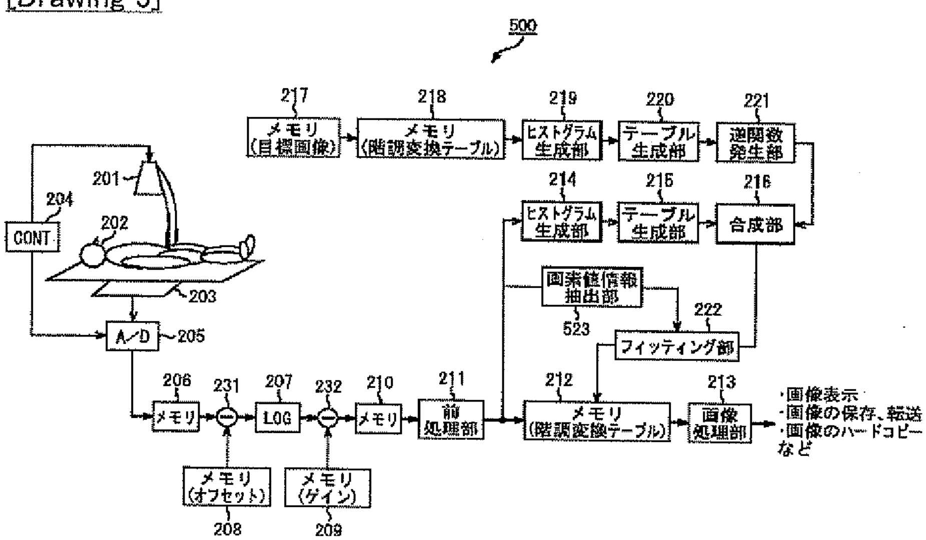
[Drawing 4]



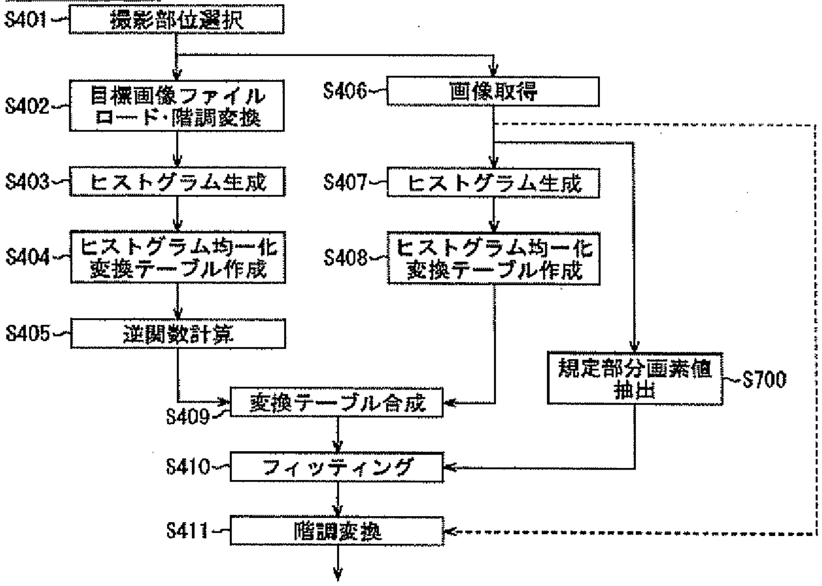
[Drawing 6]



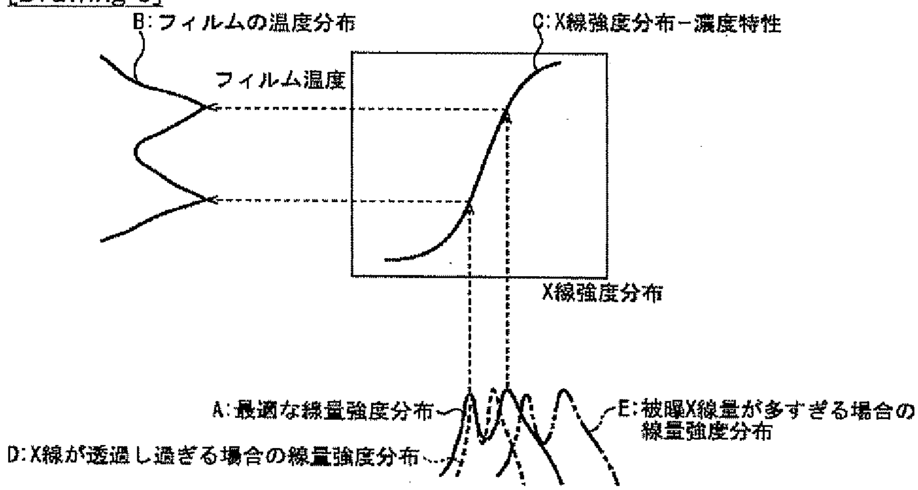
[Drawing 5]



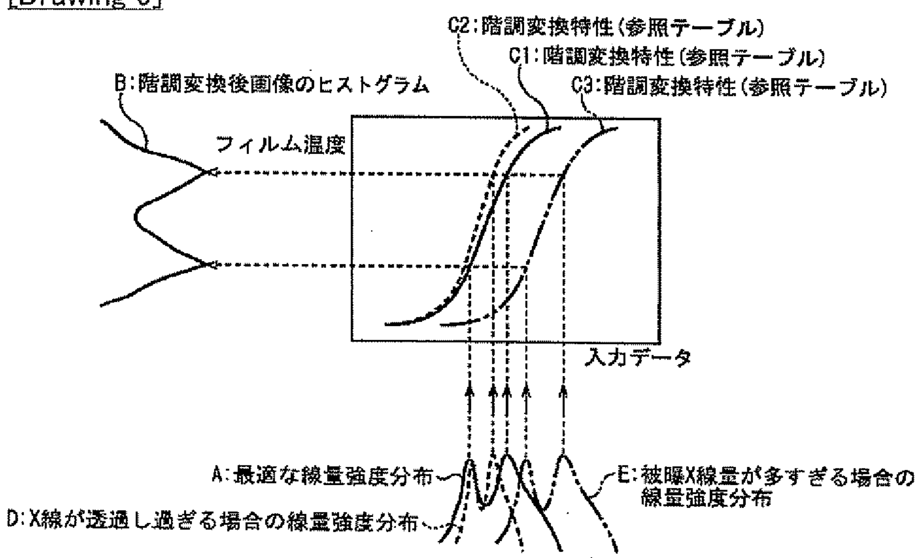
[Drawing 7]



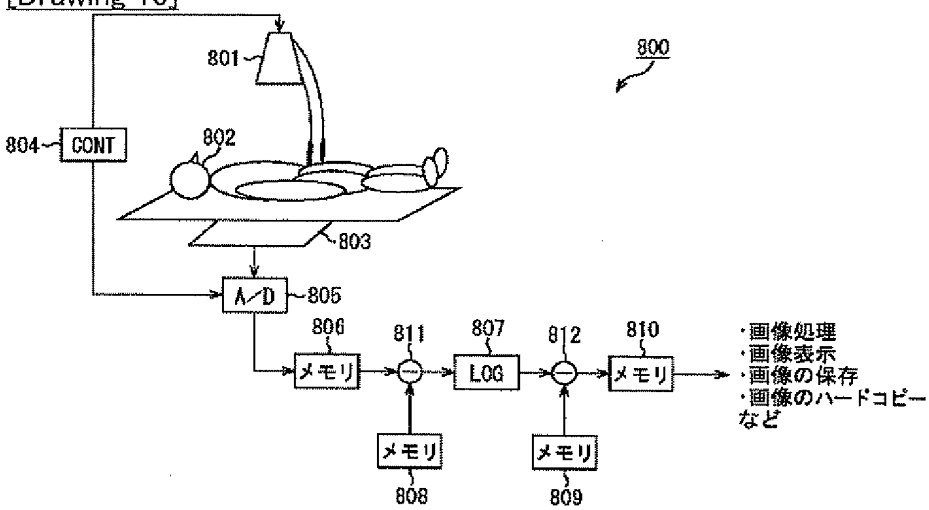
[Drawing 8]



[Drawing 9]



[Drawing 10]



[Translation done.]

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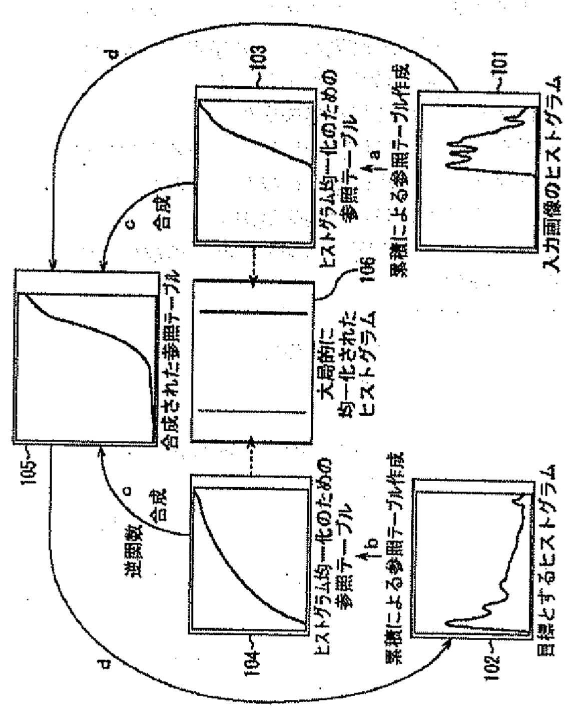
最終頁に続く

(54)【発明の名称】　画像処理装置、画像処理システム、画像処理方法、及び記憶媒体

(57)【要約】

【課題】　安定した階調変換を容易に且つ効率的に実現する画像処理装置を提供する。

【解決手段】　第１の手段２１５は、入力画像のヒストグラムを均一化するための階調変換特性取得する。第２の手段２２１は、所定の階調変換が施された画像のヒストグラムを均一化するための階調変換特性の逆特性を取得する。第３の手段２１６は、第１の手段２１５により得られた階調変換特性と、第２の手段２２１により得られた逆特性とを合成する。第４の手段２２２は、第３の手段２１６により得られた合成特性を、低次の関数でフィッティングする。第４の手段２２２での処理後の合成特性に基づき、入力画像の階調を変換する。



【従来の技術】近年における画像のディジタル化に伴って、例えば、医用Ｘ線画像についてもディジタル化が進み、Ｘ線強度の空間分布をディジタル画像（ディジタルＸ線画像）として取得することが可能になっている。

【０００３】Ｘ線ディジタル画像の取得方法としては、Ｘ線エネルギーによって輝尽性蛍光体に対して潜像を形成し、レーザによる励起光分布によってＸ線ディジタル画像を取得する方法や、Ｘ線強度の空間分布を光強度分布（蛍光）へ変換し、複数の画素を有する面センサによって直接電気信号に変換した後、Ｘ線ディジタル画像へ変換する方法、或いは、Ｘ線強度の空間分布を直接電荷の分布へ変換して、Ｘ線ディジタル画像を取得する方法等がある。

【０００４】Ｘ線ディジタル画像を取得すること（Ｘ線画像をディジタル化すること）の利点としては、

・画像データの保存や転送の効率化。

・ディジタル画像処理によって最適な画像が容易に作り出せる。これにより、撮影時の失敗を容易に回復することができる。

・医用画像診断の高効率化。

・医用画像診断の低コスト化。

等の様々な利点が挙げられる。

【０００５】特に、ディジタル画像処理によって最適な画像が容易に作りだせる、という利点は、医用画像診断という面でＸ線ディジタル画像を用いる最大の利点であり、このディジタル画像処理がなくては、Ｘ線ディジタル画像による診断は考えられない。

【０００６】具体的には、まず、従来からの、フィルム上へアナログ的にＸ線画像を出力する方法では、Ｘ線強度に対するフィルムの感光濃度特性の敏感な部分（ガンマの高い部分）を利用して、鮮明でコントラストの高い画像を作り出すようになされていた。しかしながら、このためのコントロールは主にＸ線撮影時の条件設定によって行われ、このときの撮影条件の許容範囲が狭かった。

【０００７】例えば、図８は、横軸をＸ線量、縦軸をフィルム濃度として、対数的に表した入射Ｘ線量強度分布と、その時に感光し現像されるフィルム濃度との関係“Ｃ”を示したものである。

【０００８】そこで、上記図８において、“Ａ”で示すような最適なＸ線量強度分布が得られた場合、“Ｂ”で示すような観察者（医師等）に見やすいような濃度分布を有する最適な画像が得られるが、例えば、不適切なＸ線質（管球電圧が高い→短波長（硬線）→人体吸収が少なくなる等）で撮影すると、Ｘ線量強度分布のダイナミックレンジが、“Ｄ”で示すように狭まり、適切な階調の画像が得られない。このような現象は、被写体である人体の厚みが薄い場合でも起こりうる。また、“Ｅ”で示すように、Ｘ線質は適切であっても、被曝線量が多すぎる場合、Ｘ線量強度分布全体がシフトし、やはりこの場合も適切な濃度分布を有する画像は得られない。

【０００９】これに対してＸ線ディジタル画像では、図９に示すような各種のＸ線量強度分布が一旦ディジタル値として得られる。そして、上記図２の“Ｃ１”～“Ｃ３”で示されるような、Ｘ線量強度分布に応じた各種の階調変換特性（参照テーブル）により、同図“Ｂ”で示されるような最適な階調特性（ハードコピーを行えばフィルム上の濃度特性）を有する画像が得られ、上述した撮影条件の許容範囲がかなり広がる。

【００１０】図７は、上述のような利点を有するＸ線ディジタル画像を取得するＸ線撮影装置８００の構成を示したものである。

【００１１】Ｘ線撮影装置８００において、テーブル上に横たわる人体８０２を被写体としてＸ撮影する場合、Ｘ線センサパネル８０３は、人体８０２を透過してきたＸ線管球８０１からのＸ線量の強度分布を電荷分布に変換して順次出力する。アナログ／ディジタル変換器８０５は、Ｘ線センサパネル８０３の出力をディジタル化して、そのディジタル画像データ（Ｘ線ディジタル画像データ）をメモリ８０６へ一旦記憶させる。このとき、コントローラ８０４は、Ｘ線管球８０１でのＸ線の曝射、及び画像取得のタイミングを制御する。

【００１２】ここで、Ｘ線センサパネル８０３には、画素毎にオフセット及びゲインのばらつきがある。このばらつきを補正するために、メモリ８０８には、Ｘ線管球８０１によりＸ線を曝射しないで取得した画像であるオフセット値が記憶されている。また、メモリ８０９には、被写体（人体８０２）がない状態で取得された画像であるゲイン値を対数変換したものが記憶されている。

【００１３】変換部８０７は、対数変換を行うものであり、具体的には参照テーブル（ルックアップテーブル）である。

【００１４】したがって、メモリ８０６へ一旦記憶されたＸ線ディジタル画像データは、減算器８１１によってメモリ８０８内のオフセットが減算された後、変換部８０７によって対数変換され、減算器８１２によってメモリ８０９のゲインとの差分（割り算）が取られることで、Ｘ線の強度分布画像となる。このＸ線の強度分布画像は、メモリ８１０へ一旦記憶される。その後、メモリ８１０へ記憶された画像データは、画像の保存、画像処理、画像表示、ハードコピー等のために読み出され、医用画像診断等に用いられる。

【００１５】このとき、メモリ８１０から読み出された画像データに対して、例えば、上記図９に示したような階調変換特性に従った階調変換処理が施されるが、この階調変換処理では、当該画像データ（対象画像）の取得時の状態に応じて、次のようにして階調変換特性が決定される。

（１）対象画像中の指定する任意の部位（複数或いは単数）の濃度値（出力画素値）が目標とする値となるよう

階調変換が施された画像のヒストグラムを平坦化するための階調変換特性の逆特性とを合成した階調変換特性を、低次の関数でフィッティングした階調変換特性を取得するステップを含むことを特徴とする。

【００３２】第１５の発明は、上記第１４の発明において、上記第１のステップは、上記フィッティングの際に、予め規定された濃度変換点を固定した拘束条件を持つことを特徴とする。

【００３３】第１６の発明は、上記第１５の発明において、上記第１のステップは、上記予め規定された濃度変換点のデータを、入力画像中から抽出するステップを含むことを特徴とする。

【００３４】第１７の発明は、上記第１２の発明において、上記目標となる階調変換が施された画像を、被写体における複数の撮影部位毎に複数用意することを特徴とする。

【００３５】第１８の発明は、上記第１２の発明において、上記目標となる階調変換は、操作者が自在に変更可能であることを特徴とする。

【００３６】第１９の発明は、請求項１～１０の何れかに記載の画像処理装置の機能、又は請求項１１記載の画像処理システムの機能を実施するための処理プログラムを、コンピュータが読出可能に格納した記憶媒体であることを特徴とする。

【００３７】第２０の発明は、請求項１２～１８の何れかに記載の画像処理方法の処理ステップを、コンピュータが読出可能に格納した記憶媒体であることを特徴とする。

【００３８】

【発明の実施の形態】以下、本発明の実施の形態について図面を用いて説明する。

【００３９】（第１の実施の形態）まず、対象画像に対して階調変換処理を施す際に用いる階調変換特性を任意の形状に変化させる方法としては、特開平１１－９６３５２号等に記載されたヒストグラム均一化を利用した方法がある。この方法の概要について、図１を用いて説明する。

【００４０】上記図１において、“１０１”は、Ｘ線撮影によって取得された被写体（ここでは、人体）の特定の部位の画像（入力画像）のＸ線量（画素値）のヒストグラムを示し、“１０３”は、ヒストグラム１０１を均一化する階調変換を行うための階調変換テーブルを示したものである。

【００４１】階調変換テーブル１０３は、ヒストグラム均一化（Ｈｉｓｔｏｇｒａｍ Ｅｑｕａｌｉｚａｔｉｏｎ）と呼ばれる技術によって、ヒストグラム１０１を累積して作成される。

【００４２】したがって、階調変換テーブル１０３は、入力画像の画素値を“ｘ”（Ｘｍｉｎ≦ｘ≦Ｘｍａｘ）、ヒストグラム１０１を“Ｈ（ｘ）”、階調変換テーブルを“Ｌ（ｘ）”として、

【００４３】

【数１】

$$L(x) = Xmin + \left(\sum_{i=Xmin}^{x} H(i) \Big/ \sum_{i=Xmin}^{Xmax} H(i) \right) \times (Xmax - Xmin) \quad \cdots (1)$$

【００４４】なる式（１）で表される。

【００４５】ヒストグラム１０１が得られる入力画像を、階調変換テーブル１０３によって階調変換すると、大局的には均一化されたヒストグラム１０６を有する画像が得られる。

【００４６】一方、“１０２”は、Ｘ線撮影によって取得された被写体の特定の部位（入力画像での部位と同じ部位）の理想的な状態の画像（以下、「目標画像」と言う）のＸ線量（画素値）のヒストグラム（目標とするヒストグラム）を示し、このヒストグラム１０２に関しても、上記式（１）式を用いることで、ヒストグラム均一化の階調変換テーブル１０４が作成され、大局的には均一化されたヒストグラム１０６を有する画像が得られる。

【００４７】上記のことは、目標画像のヒストグラム１０２からヒストグラム１０６を得るための階調変換テーブル１０４の逆特性（逆関数）を有する変換テーブルを作成すれば、均一化されたヒストグラムを持つ画像を、理想的なヒストグラム１０２を有する画像に変換できることを意味する。

【００４８】すなわち、ヒストグラム１０１が得られる入力画像を、ヒストグラム１０２が得られる目標画像（理想的な状態の画像）に変換するには、

（ａ）ヒストグラム１０１を均一化する階調変換テーブルＨ１（ｘ）を作成する。

（ｂ）ヒストグラム１０２を均一化する階調変換テーブルＨ２（ｘ）を作成し、その逆関数$H2^{-1}$（ｘ）を作成する。

（ｃ）階調変換テーブルＨ１（ｘ）と、階調変換テーブルＨ２（ｘ）の逆関数$H2^{-1}$（ｘ）とを合成した合成変換テーブルＨ０（ｘ）＝Ｈ１（$H2^{-1}$（ｘ））を作成する。

（ｄ）合成変換テーブルＨ０（ｘ）によって、ヒストグラム１０１が得られる入力画像の階調を変換する。

という処理（ａ）～（ｄ）を実行すればよい。

【００４９】ここで、注目すべき点は、処理（ａ）～（ｄ）では、ヒストグラムしか使用しておらず、ヒストグラムの形状を解析する等の特殊な演算処理は含まれていないことにある。そして、大局的にみれば、ヒストグラムは目標とするものに完全に一致する。

【００５０】しかしながら、画像を良好に観察したいという最終目標と、ヒストグラムを最適なものと完全に一

置２００は、上記図２に示すように、Ｘ線を被写体（人体）２０２に対して出力するＸ線管球２０１と、被写体２０２を透過したＸ線のＸ線量強度分布を電荷分布に変換して順次出力するＸ線センサパネル２０３と、Ｘ線センサパネル２０３の出力をディジタル化してＸ線ディジタル画像データとして出力するアナログ／ディジタル変換器２０５と、Ｘ線管球２０１でのＸ線の曝射及びＸ線ディジタル画像データの取得のタイミング等を制御するコントローラ２０４と、アナログ／ディジタル変換器２０５から出力されるＸ線ディジタル画像データを記憶するメモリ２０６と、Ｘ線を曝射しないで取得した画像であるオフセット値を記憶するメモリ２０８と、被写体２０２がない状態で取得した画像であるゲイン値を対数変換した値を記憶するメモリ２０９と、メモリ２０６内のデータとメモリ２０８内のデータの減算処理を行う減算器２３１と、減算器２３１での処理結果を対数変換する変換器２０７と、変換器２０７での変換結果とメモリ２０９内のデータの減算処理（割り算）を行う減算器２３２と、減算器２３２での処理結果（Ｘ線の強度分布画像データ）を記憶するメモリ２１０と、メモリ２１０内の画像データに対して前処理を施す前処理部２１１と、前処理部２１１での前処理後の画像データのヒストグラムを生成するヒストグラム生成部２１４と、ヒストグラム生成部２１４にて生成されたヒストグラムに基づきヒストグラム均一化テーブル（階調変換テーブル）を生成するテーブル生成部２１５と、目標画像データを記憶するメモリ２１７と、目標階調変換テーブルを記憶するメモリ２１８と、メモリ２１８内の目標階調変換テーブルにより階調変換されたメモリ２１７内の目標画像データのヒストグラムを生成するヒストグラム生成部２１９と、ヒストグラム生成部２１９にて生成されたヒストグラムに基づきヒストグラム均一化テーブル（階調変換テーブル）を生成するテーブル生成部２２０と、テーブル生成部２２０にて生成されたヒストグラム均一化テーブルの逆関数を発生する逆関数発生部２２１と、テーブル生成部２１５にて生成されたヒストグラム均一化テーブルと逆関数発生部２２１にて発生された逆関数のテーブルを合成する合成部２１６と、合成部２１６にて得られた合成変換テーブルを低次の関数でフィッティングするフィッティング部２２２と、フィッティング部２２２での処理後の合成変換テーブルを記憶するメモリ２１２と、メモリ２１２内の合成変換テーブルにより階調変換された前処理部２１１の出力に対して他の画像処理を施す画像処理部２１３とを備えている。

【００６４】また、Ｘ線撮影装置２００は、例えば、図３に示すような操作パネル及び表示機能を備えている。

【００６５】上記図３において、“３０３”は、Ｘ線撮影装置２００本体に設けられ、ユーザから操作される操作パネルである。“３０２（１）、３０２（２）、…、３０２（８）”は、操作パネル３０３上に設けられた複数のボタンであり、これらのボタン３０２（１）、３０２（２）、…、３０２（８）は、撮影メニューとしての被写体２０２の各種撮影部位（人体の部位１、部位２、…）に対応して設けられている。“３０４”は、階調処理条件を変更或いは確認を指示するためのボタンである。

【００６６】“３０１（１）、３０１（２）、…、３０１（８）”は、操作パネル３０３上の複数のボタン３０２（１）、３０２（２）、…、３０２（８）に対応した複数のメモリであり、これらのメモリ３０１（１）、３０１（２）、…、３０１（８）は、Ｘ線撮影装置２００内に設けられている。そして、メモリ３０１（１）、３０１（２）、…、３０１（８）のぞれぞれには、対象部位の階調処理の目標とする画像（オリジナル画像）、及びその理想的な階調変換テーブルがファイリングされている。例えば、ボタン３０２（１）に対応するメモリ３０１（１）には、部位１の階調処理の目標とする画像、及びその理想的な階調変換テーブルがファイリングされている。尚、メモリ３０１（１）、３０１（２）、…、３０１（８）のぞれぞれに記憶されるオリジナル画像及び階調変換テーブルとしては、その数に限られることはなく、１つ或いは複数のオリジナル画像及び階調変換テーブルを収めることが可能である。

【００６７】“３１０”は、Ｘ線撮影装置２００本体に設けられた表示部であり、この表示部３１０には、オリジナル画像３０５、階調変換テーブル３０６、ヒストグラム３０７、及び階調変換後画像３０８が表示されるようになされている。

【００６８】<Ｘ線撮影装置２００の全体動作：上記図１参照>先ず、コントローラ２０４からの制御により、Ｘ線管球２０１から発生したＸ線は、被写体２０２を透過して、Ｘ線センサパネル２０３上へ到達する。Ｘ線センサパネル２０３は、Ｘ線の強度分布を電荷分布へ変換して順次出力する。アナログ／デジタル変換器２０５は、コントローラ２０４からの制御に従って、Ｘ線センサパネル２０３の出力をディジタル化し、Ｘ線ディジタル画像データを出力する。このＸ線ディジタル画像データが、現在撮影が行われている被写体２０２の任意の部位のＸ線ディジタル画像データである。

【００６９】アナログ／デジタル変換器２０５から出力されたＸ線ディジタル画像データ（以下、「入力画像データ」と言う）は、メモリ２０６へ一旦記憶される。

【００７０】ここで、Ｘ線センサパネル２０３には、画素毎にオフセット及びゲインのばらつきがある。そこで、このばらつきを補正するために、先ず、減算器２３１は、メモリ２３１内の入力画像データから、メモリ２０８内のオフセット値（Ｘ線を曝射しないで取得した画像データ）を減算する。変換器２０７は、具体的には参照テーブル（ルックアップテーブル）であり、減算器２３１での減算処理後の入力画像データを対数変換する。

【００８５】上述のようにして、メモリ２１８内の階調変換テーブルが、目標画像の階調変換テーブルとして登録されると、その階調変換テーブルにおいて、<Ｘ線撮影装置２００の全体動作：上記図１参照>にて説明したようなＸ線撮影装置２００での処理が実行される。

【００８６】図４は、上述のようなＸ線撮影装置２００での階調変換処理をソフトウェアプログラムで実施するための、当該ソフトウェアプログラムの処理フローチャートを示したものである。

【００８７】先ず、ユーザは、操作パネル３０３のボタン３０２（１）、３０２（２）、…、３０２（８）により、被写体２０２の撮影する部位を選択する（ステップＳ４０１）。

【００８８】ステップＳ４０１でのユーザからの選択操作により、メモリ３０１（１）、３０１（２）、…、３０１（８）のうち、上記選択ボタンに対応するメモリ内のオリジナル画像及び階調変換テーブルはそれぞれ読み出される（ステップＳ４０２）。これらのオリジナル画像及び階調変換テーブル、オリジナル画像３０５及び階調変換テーブル３０６として表示部３１０へ表示される。

【００８９】次に、ステップＳ４０２にて読み出された階調変換テーブルにより、同ステップにて読み出されたオリジナル画像を階調変換した後の画像のヒストグラムを生成する（ステップＳ４０３）。このステップＳ４０３にて生成されたヒストグラムは、ヒストグラム３０７として表示部３１０へ表示される。

【００９０】そして、ユーザからの階調変換テーブルの調整操作が行われると、その調整操作に従って、表示部３１０での階調変換テーブル３０６、ヒストグラム３０７、及び変換後画像３０８が変更されて表示される。

【００９１】次に、ユーザが上記調整操作を終了すると、この時点でステップＳ４０３にて生成されたヒストグラムを均一化するための変換変換テーブルを作成する（ステップＳ４０４）。

【００９２】次に、ステップＳ４０４にてにて作成された階調変換テーブルの逆関数テーブルを作成する（ステップＳ４０５）。

【００９３】一方、Ｘ線撮影により、被写体の撮影画像データ（入力画像データ）を取得する（ステップＳ４０６）。

【００９４】次に、ステップＳ４０６にて取得された入力画像データのヒストグラムを生成する（ステップＳ４０７）。

【００９５】次に、ステップＳ４０７にて生成されたヒストグラムを均一化するための階調変換テーブルを作成する（ステップＳ４０８）。

【００９６】ステップＳ４０１～Ｓ４０８の処理が終了すると、ステップＳ４０５にて得られた逆関数テーブルと、ステップＳ４０８にて得られた階調変換テーブルとを合成して、合成変換テーブルを生成する（ステップＳ４０９）。

【００９７】そして、ステップＳ４０９にて得られた合成変換テーブルを、低次の関数でフィッティングし（ステップＳ４１０）、そのフィッティング後の合成変換テーブルを用いて、ステップＳ４０６にて得られた入力画像データに対して階調変換処理を施す（ステップＳ４１１）。

【００９８】尚、ヒストグラム均一化の階調変換テーブルを作成する場合、対象画像の背景情報等の無効な部分の情報をヒストグラム中から削除或いは無視するようにしてもよい。

【００９９】（第３の実施の形態）まず、画像全体の見え具合は、そのヒストグラムを、目標とするヒストグラムへ近似させることでほぼ達成されるが、医用画像ではさらに、特定の部分の画素値（濃度値）を固定して、安定した診断能を達成することが望まれる。

【０１００】そこで、本実施の形態では、本発明を、図５に示すようなＸ線撮影装置５００へ適用する。このＸ線撮影装置５００は、上記図２のＸ線撮影装置２００と同様の構成としているが、Ｘ線撮影装置２００が備える構成要件に対して、特に、画素値情報抽出部５２３をさらに設けた構成としたことが異なる。

【０１０１】尚、上記図５のＸ線撮影装置５００において、上記図２のＸ線撮影装置２００と同様に動作する個所には同じ符号を付し、その詳細な説明は省略する。

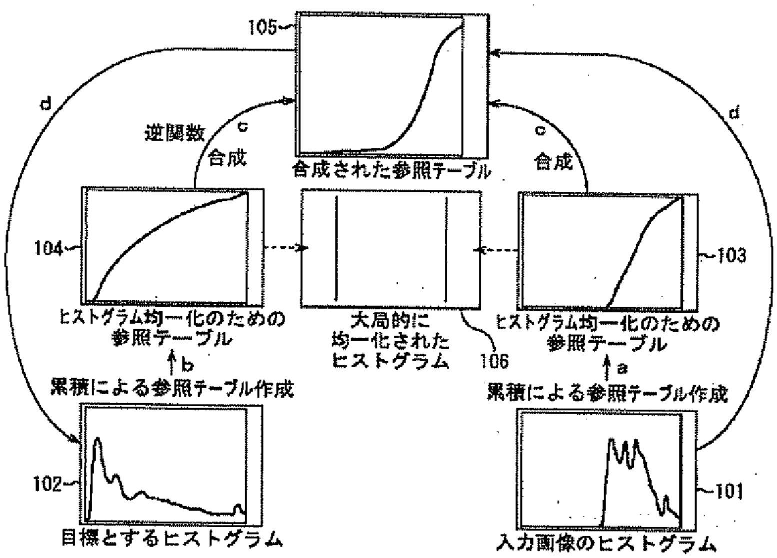
【０１０２】すなわち、本実施の形態でのＸ線撮影装置５００では、上記図３に示したメモリ３０１（１）、３０１（２）、…、３０１（８）に対して、対象部位の階調処理の目標とする画像（オリジナル画像）、及びその理想的な階調変換テーブルをファイリングすると共に、対象部位の濃度値（最終画素値）としての規定既定値｛ｙ（ｊ）；＝０，…，ｎ；ｎは１以上の整数｝をもファイリングしておく。

【０１０３】したがって、操作パネル３０３によりユーザから撮影部位が選択されると、その選択に対応したメモリからは、オリジナル画像、階調変換テーブル、及び規定既定値｛ｙ（ｊ）；＝０，…，ｎ；ｎは１以上の整数｝が読み出されることになる。

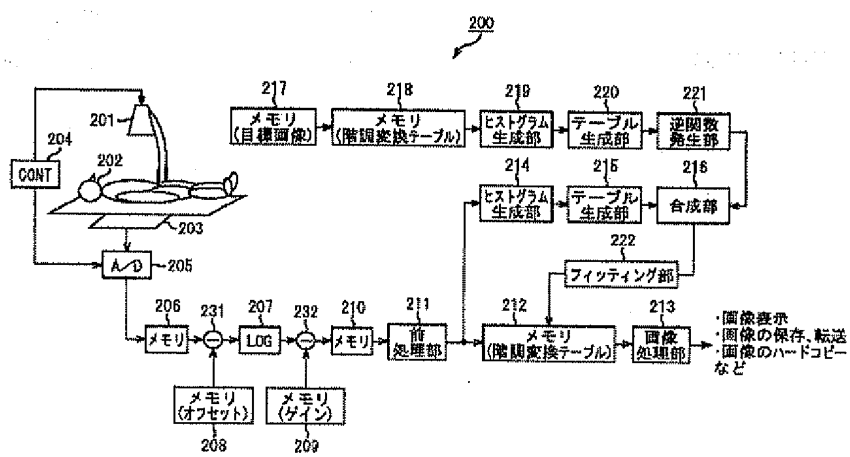
【０１０４】画素値情報抽出部５２３は、前処理部２１１での処理後の入力画像データから、規定の部分の画素値（単数又は複数の画素値）｛ｘ（ｊ）；＝０，…，ｎ；ｎは１以上の整数｝を抽出する。画素値情報抽出部５２３での画素値の抽出法としては、例えば、対象画像中の規定の位置の画素値を抽出する方法、対象画像中の規定の位置の画素周辺の画素値の平均値を抽出する方法、対象画像そのものを解析して対象画像における被写体領域の形状から特定の部分を検出し、その位置の画素値又はその周辺の画素値の平均値を抽出する方法等がある。

２０５　アナログ／ディジタル変換器
２０６　メモリ
２０７　変換器（対数変換器）
２０８　メモリ（オフセット値）
２０９　メモリ（ゲイン値）
２１０　メモリ（Ｘ線の強度分布画像データ）
２１１　前処理部
２１２　メモリ（階調変換テーブル）
２１３　画像処理部
２１４　ヒストグラム生成部
＊２１５　テーブル生成部
２１６　合成部
２１７　メモリ（目標画像）
２１８　メモリ（目標階調変換テーブル）
２１９　ヒストグラム生成部
２２０　テーブル生成部
２２１　逆関数発生部
２２２　フィッティング部
２３１，２３２　減算器
＊10

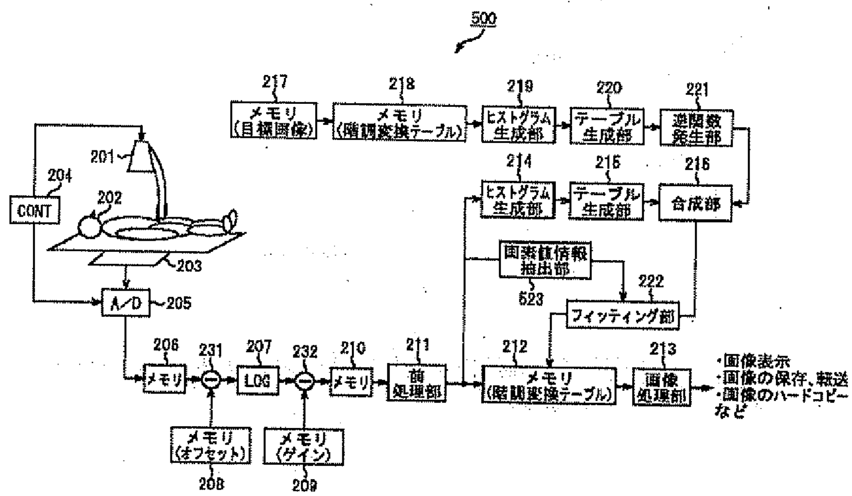
【図１】



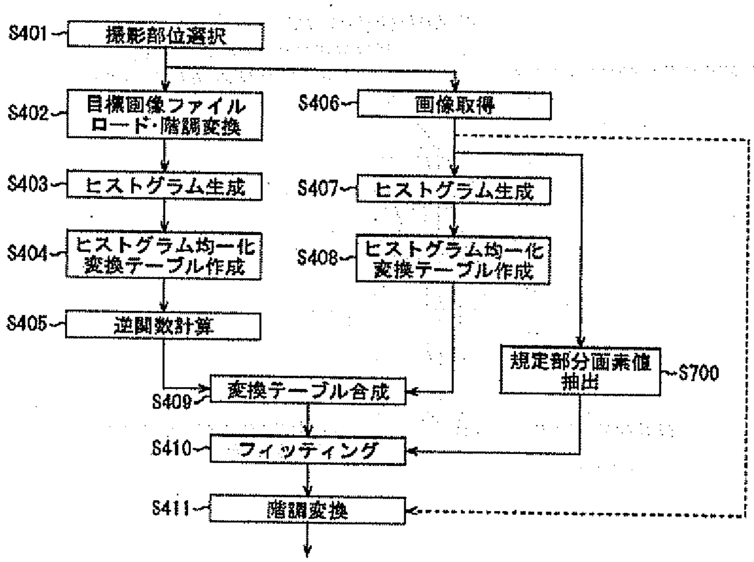
【図２】



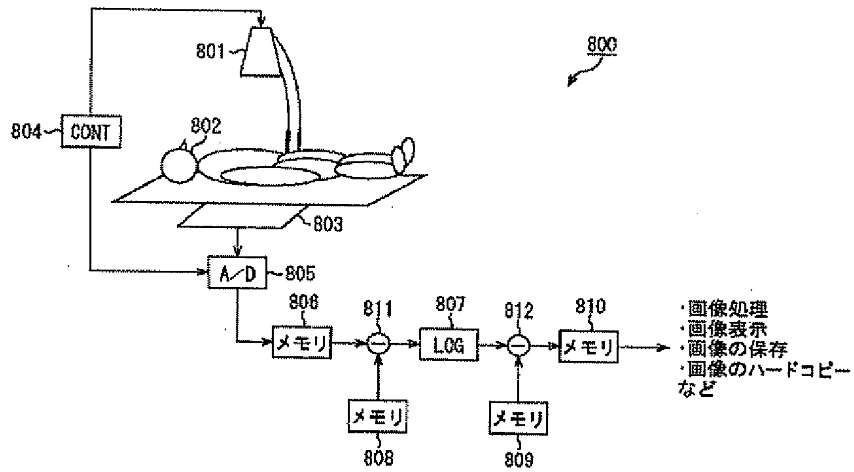
【図５】


500
217 メモリ（目標画像）
218 メモリ（階調変換テーブル）
219 ヒストグラム生成部
220 テーブル生成部
221 逆関数発生部
214 ヒストグラム生成部
215 テーブル生成部
216 合成部
画素値情報抽出部
523
222 フィッティング部
201
202
203
204 CONT
A/D 205
206 メモリ
231
207 LOG
232
210 メモリ
211 前処理部
212 メモリ（階調変換テーブル）
213 画像処理部
・画像表示
・画像の保存、転送
・画像のハードコピー
など
メモリ（オフセット） 208
メモリ（ゲイン） 209

【図７】


S401 撮影部位選択
S402 目標画像ファイルロード・階調変換
S403 ヒストグラム生成
S404 ヒストグラム均一化変換テーブル作成
S405 逆関数計算
S406 画像取得
S407 ヒストグラム生成
S408 ヒストグラム均一化変換テーブル作成
規定部分画素値抽出 S700
S409 変換テーブル合成
S410 フィッティング
S411 階調変換

【図１０】



フロントページの続き

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